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CNS Activation, Reaction Time, Blood Pressure and Heart Rate Variation During Ramadan Intermittent Fasting and Exercise

[1]S. Lotfi, [1]M. Madani, [1]A. Abassi, [2]A. Tazi, [3]M. Boumahmaza and [4]M. Talbi

[1]Laboratory of Research and Assessment in Physical Activity and Sport, CREAPS,
Superior Normal School, Hassan II-Aïn Chok University, Casablanca, Morocco
[2]Department of Pharmacology, Faculty of Medicine and Pharmacy,
Hassan II-Aïn Chok University, Casablanca, Morocco
[3]Interdisciplinary group of the Sciences Didactics, GIDS,
Hassan II-Aïn Chok University, Casablanca, Morocco
[4]Observatory of Research in Didactics and in University Pedagogy, ORDIPU,
Hassan II-Mohammedia University, Casablanca, Morocco

Abstract: The purpose of this study was to evaluate the effect of Ramadan fasting (RF) and physical exercise on CNS activation, reaction time, blood pressure and heart rate. Nine male resistance athletes aged 23 ± 3years were assessed before (Pre-R), during the 1st week (Beg-R), 4th week (End-R) and one week after RF (After-R), in critical flicker fusion (CFF), motor reaction time (MRT) and recognition reaction time (RRT), total reaction time (TRT), heart rate (HR), systolic and diastolic blood pressure at rest and after exercise. Comparing to control days (Pre-R), there were no significant changes in physical performance and weight. The results revealed a significant fasting effect for RRT ($f= 5.94$, $p<0.001$) and TRT ($f= 8.09$, $p<0.0001$) and non exercise effect on MRT and RRT ($f= 3.21$, p:ns). Fasting, exercise effect and interaction were not significant for CFF and SBP. However, the DBP at rest decreased significantly during End-R ($p<0.008$) and After-R ($p<0.012$). But HR at rest decreased significantly ($p<0.05$) of 14.26% during End-R. Ramadan had detrimental effects on some psychomotor components during the first week and a decrease on HR and DBP at the last week of fasting.

Key words: Ramadan % CNS % Reaction time % Blood pressure % Heart rate % Fasting

INTRODUCTION

Ramadan takes place in the ninth month of the lunar calendar and at different times in the seasonal year over a 33-year cycle on the Gregorian calendar. Its requires to abstain from food, drink and sexual intercourse from dawn until sunset, averaging about 15 hours a day for 29-30 days. Thus, the obligation to eat during the night leads to a definite change in the rhythm of life, sleep, eating schedule. Numerous studies have reported variation on metabolic rate[1-3], significant weight loss during Ramadan [4-6] a hemoconcentration and dehydration [2,6-8], decrease in heart rate, oxygen consumption [2,6,9], pulmonary function, RER, blood glucose concentration, triglyceride and cholesterol [10] and no effect of Ramadan fasting on blood lactate during heavy exercise in active subjects has been reported [11]. Several previous studies have reported also a decrease in physical performance and on fuel selection level during Ramadan fasting, in professional soccer players [12, 13], physically active subjects [14, 15], young athletes [16], untrained healthy subjects [17] and fighter pilots [18].

Previous studies have shown, no significant difference in the daily total caloric intake between Ramadan and regular month in adolescent soccer players, [19] healthy adult [20, 21] and in university students [22]. It has been shown that irritability increased during Ramadan. The cognitive and psychomotor tasks such as critical flicker fusion [23, 24], daytime alertness [24, 25], memory [26, 27], reaction time and mood [24], functional attention [28] were impaired by Ramadan intermittent fasting in sedentary subjects. However, in trained subjects, there is little information available on the effects of Ramadan fasting on psychomotor parameters.

Corresponding Author: S. Lotfi, Laboratory of Research and Assessment in Physical Activity and Sport, CREAPS, Superior Normal School, Hassan II-Aïn Chok University, Casablanca, Morocco

The objective of this study was to assess the effects of fasting and exercise on CNS activation, reaction time and some cardiovascular parameters in trained subjects.

MATERIALS AND METHODS

Subjects: Nine male resistance athletes aged 23 ± 3 years; studying physical education and sport at high school in Casablanca, Morocco, were accepted for the investigation with their informed consent. The above subjects were normotensive with no known history of circulatory, renal and endocrine disorders. They were instructed to abstain from any drugs during the study period. All subjects engaged in at least two-hour training sessions five times each week for 3 years and participated in official university championship competition. The subjects continued their regular training program during Ramadan.

Measurement Instruments: The physical exercise test consisted of a 1000 m run. Each subject ran from a standing position and ran 4 laps of 250 m; each subject used his own tactics to produce the best possible result. The running time for each subject was measured using an electronic timer accurate to 0.01 s; final time for the run was rounded to units of a full second (sec). Body weight was measured to an accuracy of 100 g, during all evaluation sessions, the subject wear the same short. Heart rate (HR) and systolic and diastolic blood pressure were measured at rest and after exercise during a 15-min period of recovery. The blood pressure was recorded by the tensiometer (Spengler) by the auscultatory Riva-Rocci procedure with the same procedure investigator in all experimental sessions. Heart rate (HR) was recorded (beats min^{-1}) by heart-rat monitor (Polar accurex +, Kempel, Finland). During the passive recovery period subjects were resting in relaxed sitting position. Two psychomotor tests were used: critical flicker fusion test (CFF) and choice reaction time test (CRT). CFF was evaluated using a Leeds Psychomotor Tester as described by Hindmarch [29, 30]. The threshold for flickering light fusion is widely accepted as a physiological assessment of CNS activation. The subject was required to discriminate flicker in a set of four-light emitting diodes (LED) in foveal fixture with binocular vision at about 1 m in a quiet room with a constant ambient illumination. The mean threshold was calculated using the method of limits from 6 presentations, 3 with ascending and 3 with descending frequencies (hz). CRT was also assessed on the Leeds Psychomotor [29, 30]. This test assesses (ms) the integrity of the sensorimotor system and is an accurate measure of psychomotor performance [29]. Motor time (MRT) and recognition time (RRT), the 2 components of the total reaction time (TRT) were recorded separately. Subjects were required to extinguish one of 6 led lights (randomly illuminated) by pressing the appropriate response button. The buttons were equidistant from the resting position of the finger. The reaction time recorded was the mean of five stimulus responses.

Research Design: The study was conducted in Casablanca in 2007 when Ramadan fasting occurred between October 15 through November 13. The environmental temperatures during this period were 20-25°C, with an average relative humidity of 25-37%. Experiments were performed on four separate sessions: 1) 1st week before Ramadan (Pre-R) which represents the baseline session; 2) 1st week after the start of Ramadan (Beg-R); 3) during the 4th week of Ramadan (End-R); 4) 2nd week after the end of Ramadan month (After-R). All tests were performed at 12.00-13.00h in the same order. During each session cardiovascularand psychomotor parameters were measured at rest and after exercise. The athletes woke up daily during Ramadan before dawn about 3.30 a.m. for early breakfast (Shour), prior to the morning pray and then went back to sleep, all subjects had almost the same physical activity, sleep habits and food intake schedule.

Data Analysis: Statistical analyses of the data were carried out using ANOVA for repeated measure with two factors (fasting effect and exercise effect). Post hoc testing was accomplished using Wilcoxon. Differences were considered significant when *(P*<0.05). Data were expressed as mean ± standard deviation. The data were analysed using SPSS (SPSS Inc., Chicago, IL) version 11.5. Data are expressed as mean and Standard deviation (SD).

RESULTS

The effects of Ramadan fasting, exercise effect and the interaction between these effects on all variables are shown in Tables 1 and 2.

Fig. 1 and 2 show the monthly distribution of systolic and diastolic blood pressure during initial session (Pre-R), beginning (Beg-R), end (End-R) and after (After-R) Ramadan fasting. Values presented are mean±SD.

Table 1: Body weight and physical performance measurements before, during and after Ramadan (*n*= 9). Mean ± SD

	Pre-R	Beg-R	End-R	After-R	F	p-value
Body weight (kg)	70.28 ±.49	------	70.11±6.92	70.00±6.84	.00	NS
1000 m (sec)	201.78±7.74	203.44±8.68	205.89±7.31	199.00±12.13	0.50	NS

NS: not significant

Table 2: Recognition, motor and total reaction time, critical flicker fusion and heart rate measurements before, during and after Ramadan fasting (n=9). Mean ± SD

		Pre-R	Beg-R	End-R	After-R
RRT [a] (ms)	Rest	391,00±66,03	422,02±29,65	381,81±56,24	351,30 ±31,83
	After exercise	405,19±39,05	382,59±52,49 †	375,28±44,19	333,09±23,35 *
MRT (ms)	Rest	161.96±49.59	165.46±67.27	139.15±40.20	130.94±28.95
	After exercise	142.31±29.22	157.07±47.50	143.54±66.58	117.00±33.27
TRT [a] (ms)	Rest	562.54±30.34	587.98±124.51	532.22±47.72	481.09 ±35.38 *
	After exercise	593.46±69.3	573.58±83.28 †	533.89±68.40	474.93±53.78 *
CFF (hz)	Rest	29.86±2.48	30.13±2.26	30.80±1.54	30.41±1.82
	After exercise	30.11±2.08	31.22±1.93 *†	31.32±2.04	30.58±1.69
HR [ab] (beats min^{-1})	Rest	63.11±8.75	59.00±14.14	54.11±7.75 *	66.33±8.37
	After exercise	84.78±9.97 †	88.22±9.92 †	80.56±6.69 †	89.00±14.18

Abbreviations: RRT: recognition time, TRT: total reaction time, MRT: motor reaction time, CFF: critical flicker fusion, HR: heart rate.

a: Sign. Main effect of Ramadan ($p < 0.05$) b: Sign. Main effect of exercise ($p < 0.05$)

†: Sign. Between Rest and After exercise ($p < 0.05$). *: Sign different from pre-Ramadan value (post hoc contrasts) ($p < 0.05$).

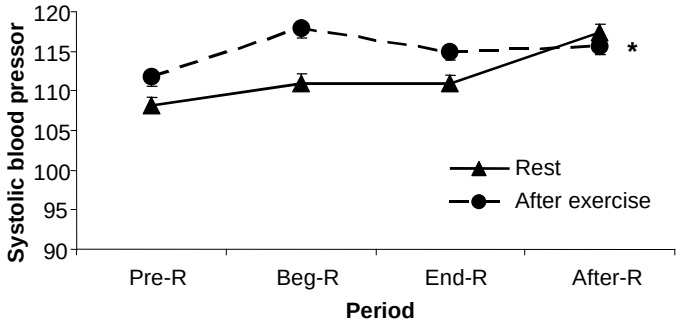

Fig. 1: Systolic blood pressure during baseline session (Pre-R), begging (Beg-R), end (end-R) and after (After-R) Ramadan fasting

Values presented are mean±S.D.

*: Sign different from pre-Ramadan value (post hoc contrasts) ($p < 0.05$).

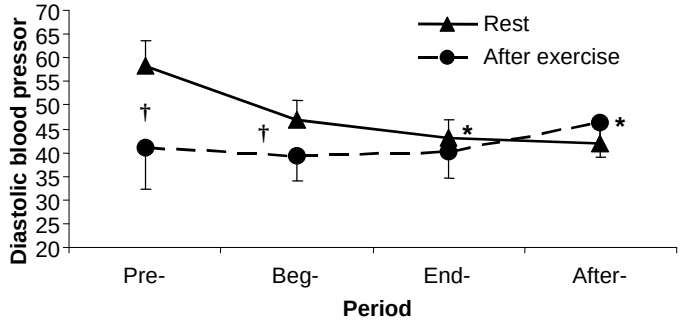

Fig. 2: Diastolic blood pressure during baseline session (Pre-R), begging (Beg-R), end (end-R) and after (After-R) Ramadan fasting

Values presented are mean±S.D.

*: Sign different from pre-Ramadan value (post hoc contrasts) ($p < 0.05$).

†: Sign between Rest and After exercise ($p < 0.05$).

The two-way ANOVA revealed a significant fasting effect for RRT ($f = 5.94$, $p < .001$) and TRT ($f = 8.09$, $p < 0.0001$) and non exercise effect on MRT and RRT ($f = 3.21$, p:ns) (Table I). The post hoc analysis showed that as compared to the initial day, RRT (After exercise) and TRT (Rest and after exercise) values decreased during Ramadan fasting but not significantly during After.R (respectively $p < 0.011$, $p < 0.038$, $p < 0.011$). Before and after exercise MRT values varied slightly with fasting but not significantly. However the post hoc analysis, showed that the exercise effect was only significant at Beg-R on RRT and TRT ($p < 0.05$, $p < .038$). Fasting effect, exercise effect and interaction were not significant for CFF.

HR, SBP and DBP values determined at rest and after exercise at Beg-R, during and after Ramadan are presented in Table 2 and Fig. 1 and 2. Fasting effect ($f = 3.109$, $p < 0.032$) and exercise effect ($f = 105.83$, $p < 0.0001$) were significant for HR. The post hoc analysis (Table 2) showed that as compared to initial day, HR at rest decreased significantly ($p < 0.05$) of 14.26% during End-R. The exercise effect was significant during rest on Pre-R ($p < 0.008$), Beg-R ($p < 0.008$) and End-R ($p < 0.008$). ANOVA revealed a non significant fasting effect for physical performance and weight. Fasting effect, exercise effect and interaction were not significant for SBP. However, the DBP varied significantly with fasting effect ($f = 2.99$ $p < 0.037$), exercise effect ($f = 8.16$ $p < 0.006$) and interaction effect ($f = 5.12$ $p < 0.003$). The post hoc analysis (Fig. 2) showed that DBP at rest decreased significantly during End-R ($p < 0.008$) and After-R ($p < 0.012$).

DISCUSSION

The main finding of this study is that psychomotor and cardiovascular parameters were affected by Ramadan fasting and exercise. Physical performance and weight were not affected by Ramadan fasting. CRT values varied during fasting, increased slightly at the 1st week and decreased progressively during and after Ramadan fasting, but did not show any exercise effect. HR and DBP were affected by the fasting and exercise effects.

There was no significant decrease in physical performance values during the Ramadan fasting period. Notably all athletes took part in regular physical activity including 5-8 sessions of resistance exercise training per week during and after Ramadan fasting. Therefore, the subjects were able to complete the entire exercise in 3-5 minutes comfortably, even though each subject underwent a running test at maximal level. The same effect was observed on moderate exercise in physically active subjects [6,31,32], on anaerobic performance in power athletes [11], speed, power, agility, endurance, dribbling skills in young soccer players [13], although some studies have observed a negative effect of fasting period on 3x 150 m, 3x 250 m performance among runners [33], on 100 and 800 m [16], speed, agility an endurance performance at soccer players [12,13] and VO2 max in healthy subjects [15]. This concordance could to be explained by the substrate selection [34-36] involved during the exercise period, level of physical condition and habitual physical training. In addition, we hypothesized that daily total caloric intake by our subjects was maintained during the Ramadan fasting [1, 19, 20, 22]. Furthermore some tendency to consume foods and drinks richer in calories (low carbohydrate) were observed in several athletes during the Ramadan than those consumed during other months [3]. The athletes demonstrated a decrease in HR and DBP during Ramadan as compared to the preceding control period, this finding is consistent with result of most studies which have shown a decrease in heart rate and oxygen consumption [2, 6, 9, 14], pulmonary function, RER, blood glucose concentration and blood lactate during heavy exercise in active subjects. This result could be related to two factors: restricted energy intake and dehydration.

Both psychomotor tests (CRT and CFF) used in this study have a motor component but the principal determinants of a performance are central and sensory processing ability [29]. Critical flicker frequency threshold measures visual discrimination and general arousal. The reliability and validity of scores obtained with the Leeds Psychomotor Tester have also been established in previous studies [30, 37]. In our study RRT and TRT varied significantly during the first week of Ramadan fasting. However, neither fasting nor exercise caused any change in the CFF and MRT when compared to RRT and TRT. These tests have been used extensively for the objective evaluation of the psychomotor reaction. The CFF test was the post sensitive measure; the CRT is also being accurate, but to a lesser extent. The main result of this study revealed that reaction time component varied by fasting, but no change in CNS activation (CFF) was found. This finding is consistent with the results of Roky *et al*. (2000) [24] which showed that Ramadan fasting had no definite effect on CFF but worsened subjective feelings (global mood and alertness). On the other hand, Legros *et al*. (1992) [38] showed that CRT and simple reaction time (TRS) was altered by the exercise effect on basketball players of the French national team, with an increase in errors. However, in our study RRT and

TRT performance were increased after exercise only in the beginning of Ramadan. In contrast, a decrease in CFF has been demonstrated during Ramadan by Ali and Mir (1989) in sedentary young adults assigned randomly to fasting or non fasting conditions and who took the test only one time during the entire experiment. On the other hand functional attention was impaired by Ramadan intermittent fasting in sedentary subjects [28]. Whereas in our work, each subject was in his own control and took the test eight times during the experiment; this may explain the differences in the results of two studies. In addition, the absence of a significant effect on CFF and SBP suggests that Ramadan does not impair the function of the sympathetic nervous system. In the present study, RRT (After exercise) and TRT (Rest and After exercise) values decreased slightly but significantly during Ramadan fasting (respectively $p<0.011$, $p<0.038$, $p<0.011$). In contrast, Audiffren *et al.* (1998) [39] observed no significant effect of exercise levels on reaction time in normal conditions. This discordance could be explained by length of the duration between the end of the exercise and the moment of the measurement data, in our *s*tudy, the observations were only measured just two minutes after the end of the exercise and some residual implicit the exercise effect on CNS activation may still occur. Consequently physical exercise can be used as a cognitive stimulant during the Ramadan fasting, it is widely used as daily social practice in the afternoon of Ramadan fasting in several Moslem countries. However the sportsmen often forget that intermittent exercise may therefore cause tiredness, drowsiness and dehydration.

Further experiments are required to determine whether training during fasting has an impairing effect on cognitive and psychomotor performance in different recovery time. We suggest that subjective assessments of feelings and psychomotor function may complete the objective tests.

CONCLUSION

In conclusion, in spite of altered sleep, activity and eating schedule, physical performance was not dramatically impairment during Ramadan fasting in resistance athletes. It appears that Ramadan has detrimental effects on recognition and total reaction time during the first week and a decrease effect on HR and DBP at the last week of fasting. There is no adverse exercise effect on motor reaction performance during Ramadan fasting. These results showed that the intermittent fasting and exercise implicate different effects on psychomotor and cardiovascular parameters.

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